An Inaugural Dissertation

On

# The Physiology of Nutrition

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How we grow and how we live, is a question which has long received the attention of Physiologists and scientific men. We select our food and eat in obedience to instinct to satisfy the cravings of hunger within, but how, and in exactly what manner the nutritious principles are taken up and assimilated, is still one of the unsolved mysteries of nature. We can follow the food, after it is taken into the mouth, through the oesophagus to the stomach and small intestine, where it is digested and its nutritive portion absorbed by the bloodvessels and lacteals, and thence conveyed through the thoracic duct to the vein. Next we see the nutritive material going to the Lungs, to be

subjected to certain changes thereby the respi-
ration, then finally started through the arteries
upon its mission. But now we approach
the disputed ground: the gulf between growth
and Decay, which has been bridged over from
time to time by innumerable theories, which
have successively fallen under the weight
of subsequent investigation and discovery.
Perhaps the present structure, may likewise
fall under future experiments, though it may
seem now, as perfect as can ever be reared while
Nature conceals her minute operations in such
an almost impenetrable obscurity.

Motion or activity, is the leading char-
acteristic of our animal life; and this motion

constant and unceasing as it is, must tend to
waste the tissues of the body. Then too every
act of mind we perform, every pain we suffer,
every emotion we express, is attended with more
or less loss of structure of the part called into
action. This is also going on continually,
whether in action or not, but it is certainly
expedited by it. Yet the rational exercise
of a part, while it wears it out, stimulates its
reproduction, and in this way maintains it
in a far higher state of integrity, than if suf-
fered to remain inactive and waste away, with
no demand except that of the vital power for
its reproduction. Thus change in the
structure, seems to be the invariable law of

organic life: that the molecules from which the tissues are formed shall live a certain time, then die, be disintegrated and eliminated, to give way for the development of new ones.

Hence, arises a necessity, that means be provided to meet this tendency to decay. This, consists in an apparatus, it may be termed, which shall prepare new materials from the chemical elements of the air and the food, to supply the waste of the old. Lest man should neglect to keep this machinery in motion, nature has given to the body certain sensations, which never fail to admonish him of the exigencies of the system, and force him to the prehension of food and drink, to

to satisfy its demands for additional nutriment.

In the present Thesis, it is not intended to consider the immense variety of substances in the animal and vegetable kingdoms which supply this waste and growth of the tissues; but only to attempt to state the processes by which this is accomplished. Nor will it be expected, that any original views can be offered upon such a subject as this, without at least facilities for experiment and observation, such as are not at the command of students of medicine. We can only hope to present, and state, the present generally received theories, in as compact and clear a form as may be in our power.

In the treatment of the subject of

the Physiology of Nutrition, it will be proper to consider briefly and in succession the several functions of Digestion, Absorption, Respiration, Circulation and Secretion, which are the main processes by which Nutrition is carried on.

First then of Digestion. This is the process the food undergoes in the alimentary canal, that its nutritive portion may be absorbed by the lacteals and bloodvessels. The first stage is carried on in the mouth. Here the food is minutely divided by mastication, and formed by mixture with the saliva into a soft pulpy mass, not only to render it easy of deglutition, but also to favor its more speedy solution in the stomach and small intestine.

This seems to be the only office of the saliva. Although it has the power of changing the starchy principles of the food into sugar, this appears to be deferred until another stage of the process.

The second stage of digestion takes place in the stomach, where the food is subjected to the action of the gastric juice secreted by glands in the walls of that organ, and poured out from them on the presence of the alimentary mass. It is not for us to discuss the various theories of Putrefaction, Fituration and Fermentation, which have been urged by different Physiologists, but adopt the generally received one of Chemical solution, which is supposed to be limited to the azotized substances. This is aided by the muscular structure of the

stomach, which by actively contracting and re-
laxing, brings successively every portion of the
food in contact with the mucus membrane, in
order that it may be thoroughly permeated by the
solvent fluid. Thus the fibrin and the albu-
men are chemically acted upon and appear to be
converted into another form called albuminose, and
from which they are later to be again elaborated.
The same change probably takes place in the
nitrogenous elements of vegetable food. In this
action the oleaginous elements are merely separated
and set free, and not chemically modified by the
stomachal digestion. As the food
dissolves and assumes the character of a creamy
pultaceous mass termed chyme, it passes from

the stomach through the pyloric orifice into the small intestine, where it undergoes the third and most complicated stage of digestion. Here it is subjected to the action of the three important intestinal fluids; the succus entericus, the pancreatic fluid, and the bile, which are capable of accomplishing the solution of the remaining elements not effected by the gastric juice. And not only by this. All the digestive fluids combined, possess the peculiar power of reducing to an absorbable condition alimentary substances of every class, thus completing the solution of food which had not been finished in the stomach. The starchy portions are converted into saccharine matter, while the oils and fats which appear to be acted

upon more particularly by the pancreatic fluid,
& are reduced to the state of an emulsion, in which
each of the minute globules is covered with a delicate
film of albumen and thus prepared for absorption
by the lacteals. We have thus
far spoken only of the digestion of solid food. That
of liquids is more simple. As neither mastica-
tion is required in their case, they are swallowed at
once and their watery portions in a great measure
& directly absorbed by the walls of the stomach, which
sift out and retain the solid and oily constituents.
The food having undergone these
changes is prepared for the absorbent process
which now commences. Absorption
is accomplished by means of the villi which

project from the inner surface of the small intes-
tine into the mass of the chyme, with every portion
of which they finally come in contact, as it is pro-
pelled along its course by the vermicular motion
of the intestines. These villi contain one or
more lacteal tubes which occupy the center, and
around them there is a minute plexus of bloodvessels.

By means of these the nutritive portion is ab-
sorbed, the fatty and part of the albuminous ele-
ments by the lacteals, but the saccharine and the
remainder of the albuminous by the bloodvessels.

The chyle, as it is now called, which fills the
lacteals, presents the appearance of a milky fluid,
owing to the fat globules it contains in a min-
ute state of division. These, enveloped by

albumen which prevents their coalescing, are sus-
pended in a fluid which contains albumen in
solution, together with certain salts taken up from
the food. After passing through the mesenter-
ic glands this fluid begins to present corpuscles
similar in form to those of the blood, and to these
the name of chyle corpuscles has been given.

Fibrin is also found in the chyle at this
stage, and has evidently been formed from the
albumen. The corpuscles become more and
more perfect and more like true blood corpuscles,
as the chyle proceeds towards its destination
through the thoracic duct to the subclavian vein,
until in the upper part of the duct, they are
often observed to present the red tinge of the blood.

The fibrin likewise increases in quantity in the same proportion. Thus, the more the chyle, resulting from the digestive process, approaches the point where it goes into the circulation, the more it possesses the chemical and microscopical appearance of the blood, which nature has intended it should renew. Through the same channel, the thoracic duct, there is also thrown into the current of the circulation, the lymph collected by the lymphatic vessels, from all parts of the body. The commencements of these vessels cannot be clearly traced, but they seem to originate in the substance of the tissues, by vascular networks, somewhat similar to those of the capillary bloodvessels. From these

convergent trunks arise, which, like the lacteals, enter and are distributed to the substance of glands, in this case the lymphatic: then after converging, finally terminate in the thoracic duct, which empties empties into the left subclavian vein. Another duct, called the right lymphatic, receives the lymph from the right upper extremity, and terminates in the right subclavian vein.

The lymph is an albuminous fluid, clear, instead of milky, like that of the lacteals, owing to the absence of the minute particles of fat. Lymph corpuscles and fibrin are seen after the fluid emerges from the glands, and as before, the first become more perfect, and the quantity of the latter greater, as

they approach the circulation. But these corpuscles are entirely colorless. The lymphatics evidently perform an important part in the renewal of the blood, but differ from the lacteals, in that the renovating elements they elaborate and contribute, are derived not from the food but from the blood itself, and from the disintegration of the tissues, by taking up that portion which is capable of being again assimilated, or of undergoing some new transforming or renovating process.

But at this point, we must not overlook the action of the liver, in the elaboration of nutrient materials. It has been stated, that part of the chymous fluid, is absorbed by the bloodvessels of the villi. This, together with

that also absorbed by the walls of the stomach,
is conveyed by the portal vein to the liver, there
to be subjected to its action. What this is, Phys-
iologists are not exactly agreed upon. Whether
it is the taking up of certain components of the
nutritive matter, and preparing them for being
introduced into the current of the blood; or col-
lecting materials for the formation of the bile, is
not known, but it is probably both. Certain
it is, that sugar is formed in the substance of the
liver, and is found there too in greater quantity
than is brought there by the portal vein.
And this saccharine matter is found in the
hepatic vein, and at certain times, after diget-
ion, in the general circulation. This fact

would naturally lead us to suppose that it is to be decomposed in the circulation, and become subservient to the nutrition of the blood.

We have seen that the fluid which enters into the circulation, by passing from the thoracic duct into the subclavian vein, presents the appearance of new blood. This new lacteo-lymphatic blood, passes to the right auricle and ventricle of the heart, with the venous blood from all parts of the body. Thence, it is propelled to the lungs, where the chemical changes of the third function, that of Respiration, take place.

This function we now proceed to consider. Thus far, each succeding step has

seemed to be of more immediate vital importance
to human life, than the preceding. Thus, life
continues for a time, and absorption is carried on
from the disintegration of the tissues, during star-
vation; and respiration continues, even when as-
similation is imperfect or suspended, as in maras-
mus. But life quickly ends in Asphyxia,
when the respiration is suspended, and the
blood denied its requisite supply of oxygen, and
its deleterious components cease to be exhaled.

Not only, must the nutrient material pass
through the lungs, and there undergo certain
changes before it can carry out its mission; but
the blood also must thereby be enriched and
arterialized, by taking in oxygen and exhaling

the Carbonic acid taken up in the circulation.

Such is seen to be the case. The atmosphere inspired, is composed principally of 79 parts of nitrogen and 21 of oxygen. The expired air, has lost part of its oxygen, and acquired a large amount of carbonic acid and watery vapor.

At the same time, a considerable portion of carbonic acid passes off through the skin, which thus greatly assists the lungs. According to the theory now generally received, this Carbonic acid is formed in the ultimate tissues of the Economy, by the union of the Oxygen carried by the Arterial blood to the capillaries, with the carbon resulting from the disintegration of these tissues, and that supplied by the food and

not converted into tissue. But part only of the oxygen which disappears during respiration, is thus consumed. The remainder, is generally supposed to be taken up in the more intimate or capillary structures of the body, and to combine on the one hand, with the albumen which forms the new tissues, and on the other, with the nitrogen of the decomposing nitrogenous tissues; and with the sulphur and phosphorus of the body to form the sulphates and the phosphates excreted in the urine. Water is also formed by the union of part of the Oxygen, with the hydrogen of the tissues, and the food elements; and this is exhaled from the lungs in the form of a watery vapor. Respiration also occasions

a great change in the blood itself. It loses its dark crimson venous hue, and assumes the bright scarlet color of arterial blood. Its temperature is raised, while it is purified and vitalized, for the work it has to do in the nutrition of the body.

Regarding the function of Circulation. much need not be said, though of equal importance with any other; for upon the proper and healthy maintenance of this, depends the normal activity of all the parts of the organism.

Without discussing the various theories of the different forces by which this is carried on, we have only to state the part it performs in the nutrition of the body, upon which Phys-

iologists are generally agreed. Conveying
the venous blood from every part of the body,
together with the recently absorbed products of
the lacteals and lymphatics, through the heart
to the lungs to be there vitalized and converted
into arterial blood, the circulation, has for its
object to distribute to every part of the organism,
the materials necessary for its growth and ren-
ovation, with the supply of oxygen for its vital
actions. This it does through the medium
of this arterialized blood, which holds in solu-
tion all the ingredients necessary for the forma-
tion of the tissues. In its circuit too through
the different organs and capillaries, the blood
takes up or absorbs whatever substances are to

be conveyed to and thrown off, by the various excretory organs situated in the different parts of the body. At the same time, the vessels are to convey the blood to those glands, whose special functions Physiologists have either not yet discovered, or at least not agreed upon what they are; but which, are generally supposed to perform a very important part in the formation of the blood itself and its corpuscles.

We come now, to the last great function immediately concerned in the process of nutrition, that of Secretion. This will be considered so far only, as it assists in the work of assimilation of the constituents of the blood by the tissues, by depositing in each and every one from

the blood, the elements there held in solution, and which they demand for their growth. Having considered the taking of food with the several processes the nutrient materials undergo in the preparation, and the manner in which they are conveyed to the tissues, it only remains now to state the generally received theory of how these are taken up. Of course, all that can be said upon assimilation must necessarily be founded on theory alone, for these operations of the economy are so minutely carried on, that no eye can ever view them in action. Thus Nature concealing her processes, exhibits only the effects or results of her work in the organism.

And these will be more or less perfect, as

proportion as the latter is fully performed.

We know that when the normal supply of blood is partially cut off from any part or organ, it becomes atrophied; and if the supply be entirely cut off such part dies, and henceforth remains as a foreign body until absorbed or removed.

The developement of the organic tissues, is generally supposed to be accomplished by means of the cells of which they are composed.

In the obzure and mysterious function of Secretion, the minute divisions of the systemic capillaries bring the arterial blood in connection with the various structures, penetrating them in every direction and spreading a network on their surface. These different

tissues of the body, seem to have the vital power of selecting from the blood, the elements and the various salts they require for their growth, and for the repair of the waste constantly taking place in them. Thus it is, that the bones extract the phosphate of lime which form so important a part of their composition, and that the other tissues, select the salts which predominate in their structure. In each case, the selection is made by each by the inherent vital power of efficiently appropriating and transforming into its substance, the elements presented to it in the course of the circulation.

This, to use the words of a prominent writer, is supposed to go on in such a way that

"the abstraction of the material required for one part leaves the blood in a state fitted for the nutrition of other parts;" and again "that such a mutual dependence exists amongst the several parts and organs of the body, as causes the evolution of one to supply the conditions requisite for another." And "this takes place that the normal composition of the blood may be maintained without waste of substance, by the existence of such a ballance between the appropriate action of the several parts, as shall cause a certain equivalent of blood to supply, without deficiency or surplus, the materials which they collectively require." A remarkable fact, in the history of nutritive growth and repair of waste

is, as the organ grows and is repaired, it retains its primitive mould and shape. Even accidental peculiarities of the body, are faithfully reproduced such as a scar or cicatrix.

Thus although the cells change, the form remains the same: the newly added matter merely increasing the bulk, and replacing the disintegrated parts, varying according to the age of the individual. When the tissues have lived their time, the chemical elements of which they are composed are broken up and removed, to make way for new cell formations.

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